Frontiers in Environmental Engineering (FIEE) Volume 5, 2016 www.seipub.org/fiee
doi: 10.14355/fiee.2016.05.001

Climate Change Impact of the Caspian Sea Level Changes in the Quaternary Sediment

Alireza Ghodrati[*1], Payam Alemi Safaval[2], Mir Ahmad LashtehNeshaei[3]

[*1]Scientific Member, Agricultural and Natural Resources Research Center of Guilan,Rahst, Iran

[2]Bcs.in Geography-Cartography,Guilan Center of Geoscience, Geological Survey of Iran

[3]Associate Professor,Faculty of Engineering,University of Guilan,Rasht, Iran

[*1]ghodrati_2000@yahoo.com; [2]Alemi.payam@gmail.com; [3]maln@guilan.ac.ir

Abstract

In recent years, the coastline of Caspian Sea in Guilan province, especially the estuary of big rivers such as Sefidroud delta has changed increasingly due to the environmental, continental and marine factors. The changes in the position of these coastlines have led to some damages. The changes of water level that come from the land, the differences in the land sediment levels and the situation of erosion in the coastline's sediments such as continental factors and the changes of sea level and the patterns of current and Caspian Sea waves are the some changes that occur in Caspian Sea's coastlines. The purpose of this study is to investigate the causes of these factors in different regions of Guilan's coastlines. Using aerial photos in the two periods of years in 1967 and 1994 with the scale of 1/20000 and software's such as ILWIS, Photoshop sediment levels are estimated. Some geographic and topographic mapswith the scales of 1/20000, 1/50000, and space measurements are used in order to complete the information in this research. The sedimentary units used in this study in geography are called Quaternary unit. These units in the sedimentary environment are Qt1, Qt2 and QM, which are related to land environment. Qts, Qsp units belong to land and Qt1, Qt2, Qt3 are related to river environment and finally the Q2be, Q2b, and Qbm units are related to middle and under coastline. The Guilan's coastline progress under the sea erosion was estimated in Astaneh-Ashrafiye 84.08 ha, Talesh 49.52 ha, Anzali 45.87 ha, Lasko-kelaye 1430.69 ha and Roudsar 678.5 ha. Retrograde under the coastline's sediment was estimated in Astaneh-Ashrafiye 276.99, Talesh 48.31, Anzali has no retrograde, Lasko-kelaye 2.04 and Roudsar 5.46 ha.

Keywords

Water Advancement; Changes In Sea Level; Caspian Sea; Guilan Coast; Shore; Sedimentation

Introduction

The length of Caspian Sea in Guilan province, from Astara border to the last border of this province, is about 320 km and its width at the broadest point is 50 km and in the narrowest point is 100 m. The important rivers which pour into the Caspian Sea through the southern basin include: Sefidroud, the source of which is located away from the Caspian Sea shores. In addition, there are some small rivers from more than 74 basins which are located in the southern areas of the Caspian, in Guilan province. Guilan province has a moderate humid weather throughout the plain and the low lands along the shoreline from Roudsar to Astara. The wind velocity rises to the highest point of 8.8 km/h in winter and decreases to the lowest point of 4.3 km/h in April. The rate of rain across Guilan coastlines is varied from 980 mm to 1900 mm. Four periodical characteristics were identified from the beginning of systematic observations of the water level (in 1830): a relatively consistentperiod during 1830-1929 (-25.5 m) a rapid decrease by 1.7 m during 1930- 1941[1] and then, in 1942-1977 there was a rapid decrease. At the end of this period, the level of Caspian Sea was at the lowest point in the last 160 years, which was -29 m [2]. The total rate of decrease in the water level between 1900-1977 was 3 m [3]. Since 1978 the level of Caspian Sea has increased and now it has a relative increase of 2.55 m [4].The transformation in the level of Caspian Sea is possibly the result of a factor or a combination of different factors such as: climate change, technical activities, and human activities. The role of each factor in the total change of sea level isn't the same as the others [5].

Concerning the topological structure, the coastal area of Guilan situated between the two coastal regions of Astara to Poonel and Poonel to the border of Mazandaran province, is considerable. In the western area of Guilan, the present time's coastal terraces have formed a band with a width of 2-8 km the formation of which is related to intense topological movements of Astara fault.

The depositions in the coastal area often consist of settles and alluvium boulders which are separated from elevations. The coastal profile deposits are relatively in variation from rubble–stones to sand. The land morphological views of the coasts of northern Iran are formed due to the influence of different topological phenomena- hydrodynamic and climate.

Most of these views, like Sefidroud river delta's sandy banks, the plains and coastal torrential fields, are a part of the group of views resulting from the deposition and transfer of deposits from land, marine depositions, the waves and marine currents all of which are influential in their formation.

Due to the depth of the sea in the southern coasts, decrease and increase in the sea level during various periods has had no considerable effect on it and has had less in scission. The coastal edge in Guilan consists of accumulated deposits by rivers and dunes. In most areas, the dunes cause a break between sea and ponds. In the areas in which rivers enter the sea, the coastline is clotted and often a swamp is created at the mouth of the river.

Methodology

The Caspian Sea is the biggest lake in the world which is located in the north of Iran and the South of Russia and it is in between northern latitude in 33'and 360 (the southwest area) until 470 and 7′ (the northeast area) and east distance 460 and 43' western until 540 and 50' eastern. Guilan province has a temperate and humid weather. In addition, it includes all plains and low coastline. In this study, some library information is used by viewing the previous works, the space measurement, and GIS. Some information was achieved from the aerial photo 1/20000 of year 1967 and 1/2000 of year 1994 and topography maps 1/50000 and geography maps and satellite images and meteorological statistic and wave statistic, some scientific reports and related articles and some books about various coastlines belonging to the common wealth countries around the Caspian Sea.

The isolation of images between the years 1967-1994 was in the form of aerial scan as a Gray Scale and with 200-250DPI. The images of scan did not cover marginally the whole area and the images had the numbers providing photo Mosaic Orthrophoto. They used graphic designing softwares such as Photoshop. To unify the color of aerial photos, they used light and shade. They used the skewed tools in order to unify the map. Based on Topography maps, the connecting of images provided in a sector of 15'. The result of this function was in a distance of 15' and in the coastline area. After that, the limit of the image was sent to ILWIS environment for drawing and other functions.

The GIS studies of Caspian Sea's coastline provided a classic study, input, process, and output of information and maps. The aims of this study were to determine the position of erosion and sediment in coastline and the natural factors in the photography of two periods, and to determine the location of sediment and erosion.

Results and Discussion

The Caspian Sea in Guilan province and its impression on the morphological transformation of the coasts in two periods have been reviewed. The water proceeding in the coastal areas of Guilan has a fundamental role in geomorphological transformations and deposit coastal units and transformation in their position. The erosion and deposition phenomena are concentrated mainly on specific areas, across the Caspian coast, and coast lands which have transformed under the influence of these processes, the division is done from a geomorphological point of view and same maps are provided.

Geomorphologic forms resulted from deposition in the region to different sedimentary environments, and on the basis of the kind and the constructive power, deposits are created in different environments of these forms, the ponds and coastal swamps[6].

Lagoons and Swamps

There are many morphological views which are observable in different of Guilan's coastal regions.

The sea water proceeding and the entrance of rivers from upstream have resulted in the creation of these regions and have led to the trapping of deposits among them; meanwhile, the continuation of this matter has caused the expansion of the lagoon coastlines in a wide range of the Caspian Sea coasts.

Anzali Gulf: The most famous gulf of the region can be said to be the Anzali Gulf which is located in the southwestern part of the Caspian Sea and is 40 km away from Rasht, which is separated from the sea by means of a narrow band of sandy land.

Dune, Sandy Bank, Sand Plain Splits

One of the important bars and the geomorphological views of the coastal area under study are dunes which are found in coastal regions. These dunes are under erosion and movement by means of waves and the blowing of wind in the region. The dunes in the region are most often in the form of transversal dunes.

Delta

In the coastal regions of Guilan, the great delta of Sefidroud is the most famed delta in Caspian Sea. In addition, it can be seen in Krgan-roud and other parts of Guilan. Eroded deposits and coastal shores under deposition and untransformed varieties in Sefidroud Delta facing the Caspian Sea in the Kiashahr region is clearly distinguishable.

Marine Terraces

Marine terrace is another land morphological view of the eastern coasts of Caspian Sea the formation of which is related to the change of seawater level in a long-term period. The reasons for these vacillations, are the change in climatic conditions and the geological activities of Caspian Sea bed. Generally in the area, three alluvium terraces in different levels of elevation are observable:

Flood Plains and Muddy Areas

One of the forms that resulted from deposition in the coastal plains and which belonged to the circumstances of the river, is flood and muddy plain.

Alluvial Fan

At the foot of the coastal terrace areas under study, where the elevations with steep gradient are limited to plains, the Conical shape deposit accumulations are created. These shapes can be seen in Talesh, Khotbeh-Sara River. The general length of the coast is relatively parallel with Astara fault and its direction is northern–southern. The sandy bands among relatively great rivers are formed in the shape of parallel and curved bands.

Estuaries or Shallow Holes

These holes, behind the sandy coasts, are created due to water proceedings in which the water has proceeded and retreated in a dry environment and after its retreat from these estuaries, has created specific scenes and views and into which some rivers flow.

On the basis of space measurement and some pervious results, it is known that the causes of the changes in the sedimentary units were from different processes, such as coastline erosion (progressing), sedimentary layers (under grading), making new sedimentary units and human activities in making ports, roads, cities and creating some small ponds behind the sandy hills and also some changes that occur in coastline's morphology [7].

Talesh region (Hashtpar): The western coastline of the Caspian Sea in Talesh region, by leaving the sediments,progress toward the sea nearly in distance 31.48 ha. This region by the leaving sediments from rivers has created a coastline in distance 15.75 ha. In addition, some areas that have remained under the rivers' sediment are in distance 3.52 ha. The patterns of progressing and sediment are in Talesh (table 5).

Bandar Anzali region: Based on the results, almost all of the profile of the coastal region of this map is dominated by coastal erosion and proceeding patterns and the extent of the area along the Anzali coast is 45.81 ha. (table 1).

Astaneh-Ashrafiye region: This region and Kiashahr coastline has a particular morphology because of the entering of the water of Sefidroud River and the transporting of sediment and some short and long time changes in the movement line. This region has a completely different form. The sediment space is 59.10 ha, while in the coastline it is about 276.99 ha. Under grading of water and coastline, sediment is about 48.08 ha (table 2).

Lasko-Kalaye region: This region extends towards Langroud and has a sandy coastline. This coastline has a curvature. The coastline sediment space in this region is at a distance of 1430.69 ha. This progress is the largest in the coastline region of Guilan province and the area under sedimentation is very limited and small and is about 2.04 ha (Table 3). The dominant pattern in this area is sedimentation and water progression.

Roudsar region: This region is the continuation of Langroud coastline and stretches toward Chaboksar. It has a sandy coastline. The dominant pattern of this region is the sediment pattern and water progressing. Moreover, its area is 678.50 ha. It is the second area concerning the changes in the province. Sedimentation occurs at the center of Roudsar which is around the western mouth of Puleroudriver, and its area is about 5.46 ha. The rate of erosion in the channels and rivers is 51.68 ha and the highest rate of sedimentation is about 84.68 ha (table 4). The coastline profile has extended toward the sea.

TABLE 1 SEDIMENTARY DEPOSITION CHANGES OF TWO PERIODS IN BANDAR ANZALI REGION (1967-1994)

Row	Units	Area(ha) (1967)	Area(ha) (1994)	Changes (ha)
1	Backshore	45.08	33.87	-11.20
2	Farms	49.81	27.17	-22.64
3	Qal1	43.35	52.97	+9.62
4	Qsp	418.94	0	-418.94
5	Qt2	105.73	192.002	+86.272
6	Qts	68.78	585.45	+516.67
7	lagoon	74.24	1857.61	1783.37
8	Urban areas	48.73	173.77	+125.04

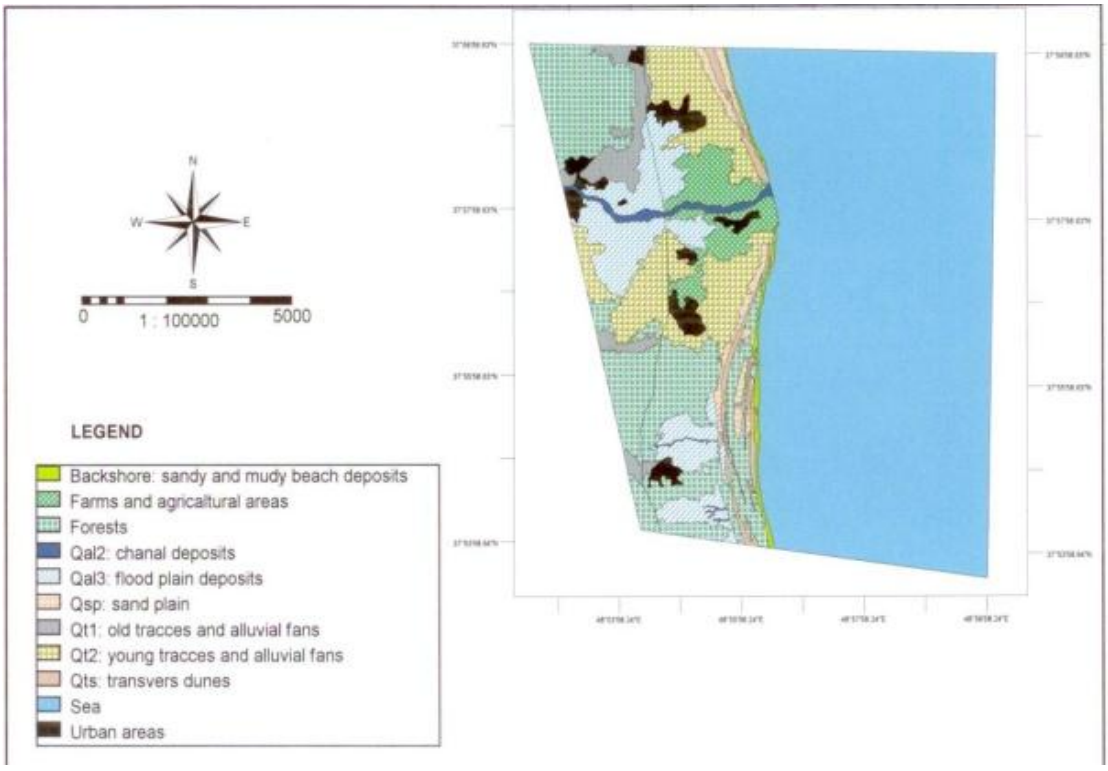

FIGURE 1 MAP OF SEDIMENTARY UNITS AND GEOMORPHOLOGY SHAPES IN TALASH-HASHTPAR-ZONE ON AERIAL PHOTOGRAPHY(1967)

FIGURE 2 MAP OF SEDIMENTARY UNITS AND GEOMORPHOLOGY SHAPES IN TALASH-HASHTPAR-ZONE ON AERIAL PHOTOGRAPHY(1994)

TABLE 2 SEDIMENTARY DEPOSITION CHANGES OF TWO PERIODS IN ASTANE REGION (1967-1994)

Row	Units	Area(ha) (1967)	Area(ha) (1994)	Changes (ha)
1	Backshore	207.97	65.10	-142.87
2	Farms	1017..97	181.48	-836.49
3	Qal1	353.35	476.68	+123.28
4	Qal2	169.69	103.87	-65.82
5	Qal3	1958.12	597.38	-1360.74
6	Qt2	2079.15	1786.39	-292.76
7	Qts	602.12	338.58	-263.54
8	Lagoon	624.95	235.45	-389.5
9	Urban areas	78.86	14.20	-64.66

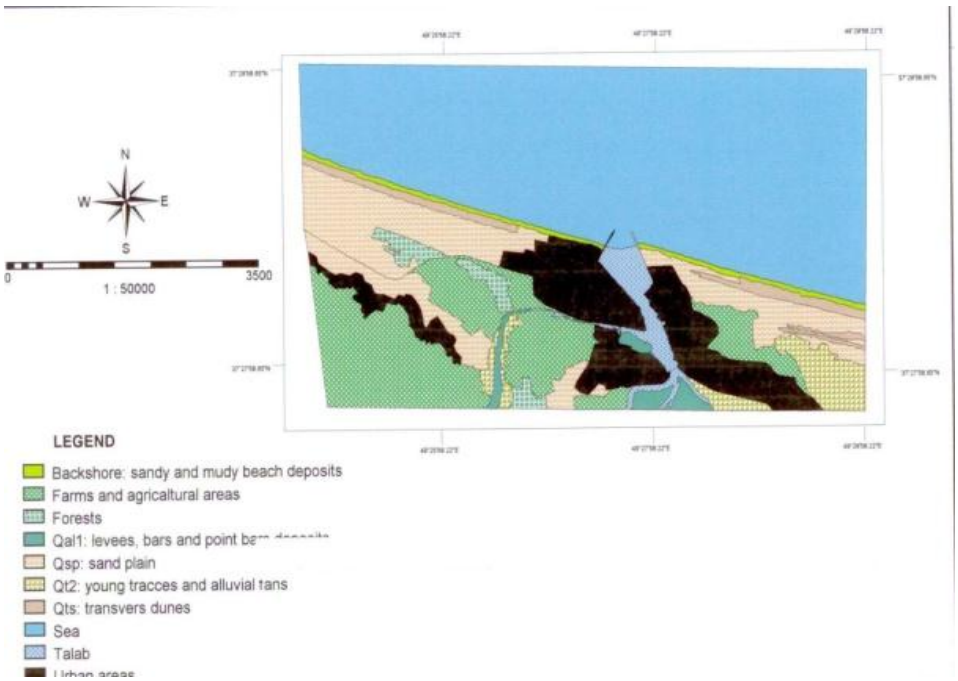

FIGURE 3 MAP OF SEDIMENTARY UNITS AND GEOMORPHOLOGY SHAPES IN ANZALE -ZONE ON AERIAL PHOTOGRAPHY(1967)

FIGURE 4 MAP OF SEDIMENTARY UNITS AND GEOMORPHOLOGY SHAPES IN ANZALE -ZONE ON AERIAL PHOTOGRAPHY (1994)

TABLE 3 SEDIMENTARY DEPOSITION CHANGES OF TWO PERIODS IN LASKUKLAYE REGION (1967-1994)

Row	Units	Area(ha) (1967)	Area(ha) (1994)	Changes (ha)
1	Backshore	325.94	106.41	-219.53
2	Farms	1963.58	145.64	-1817.94
3	Qal1	14.81	0	-14.81
4	Qal2	60.37	35.08	-25.29
5	Qal3	3122.08	1843.14	-1278.94
6	Qsp	134.45	1283.33	+1148.88
7	Qt2	7431.81	2646.32	-4785.49
8	Qts	1563.03	366.57	-1196.46
9	lagoon	600.01	402.58	-197.43
10	Urban areas	111.94	47.35	-64.59

FIGURE 5 MAP OF SEDIMENTARY UNITS AND GEOMORPHOLOGY SHAPES IN ASTANEH_ASHRAFIEH - ZONE ON AERIAL PHOTOGRAPHY (1967)

FIGURE 6 MAP OF SEDIMENTARY UNITS AND GEOMORPHOLOGY SHAPES IN ASTANEH_ASHRAFIEH -ZONE ON AERIAL PHOTOGRAPHY(1994)

TABLE 4 SEDIMENTARY DEPOSITION CHANGES OF TWO PERIODS IN RUDSAR REGION (1967-1994)

Row	Units	Area(ha) (1967)	Area(ha) (1994)	Changes (ha)
1	Backshore	332.88	143.88	-189
2	Farms	1889.22	653.85	-1235.37
3	Qal1	176.52	173.79	-2.73
4	Qal2	247.97	366.04	118.07
5	Qal3	665.66	3675.48	+3009.82
6	Qsp	1559.91	920.14	-639.77
7	Qt1	56.52	12.14	-44.38
8	Qt2	8238.07	6556.45	-1681.62
9	Qts	347.61	43.63	-303.98
10	Rock unit	347.61	76.49	-642.44
11	Lagoon	79.80	82.78	+298
12	Urban areas	87.84	124.70	+36.86

FIGURE 7 MAP OF SEDIMENTARY UNITS AND GEOMORPHOLOGY SHAPES IN LASKUKLAYE -ZONE ON AERIAL PHOTOGRAPHY(1967)

FIGURE 8 MAP OF SEDIMENTARY UNITS AND GEOMORPHOLOGY SHAPES IN LASKUKLAYE -ZONE ON AERIAL PHOTOGRAPHY(1994)

TABLE 5 SEDIMENTARY DEPOSITION CHANGES OF TWO PERIODS IN HASHTPAR-TALASH REGION (1967-1994)

Row	Units	Area(ha) (1967)	Area(ha) (1994)	Changes (ha)
1	Backshore	70.48	124.24	+53.76
2	Farms	381.71	1037.28	+655.57
3	Qal1	-----	275.44	+275.44
4	Qal2	83.08	424.89	341.81
5	Qal3	791.16	1315.60	+524.44
6	Qsp	166.54	424.95	+258.41
7	Qt1	271.53	144.74	-126.79
8	Qt2	899.51	7248.68	+6349.17
9	Qts	152.36	227.21	+74.85

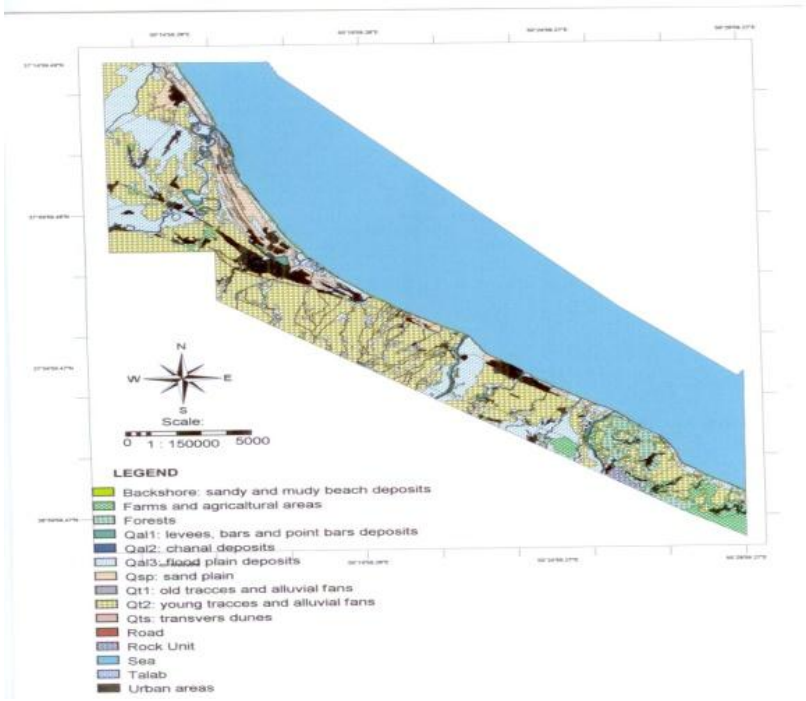

FIGURE 9 MAP OF SEDIMENTARY UNITS AND GEOMORPHOLOGY SHAPES IN RUDSAR - ZONE ON AERIAL PHOTOGRAPHY (1967)

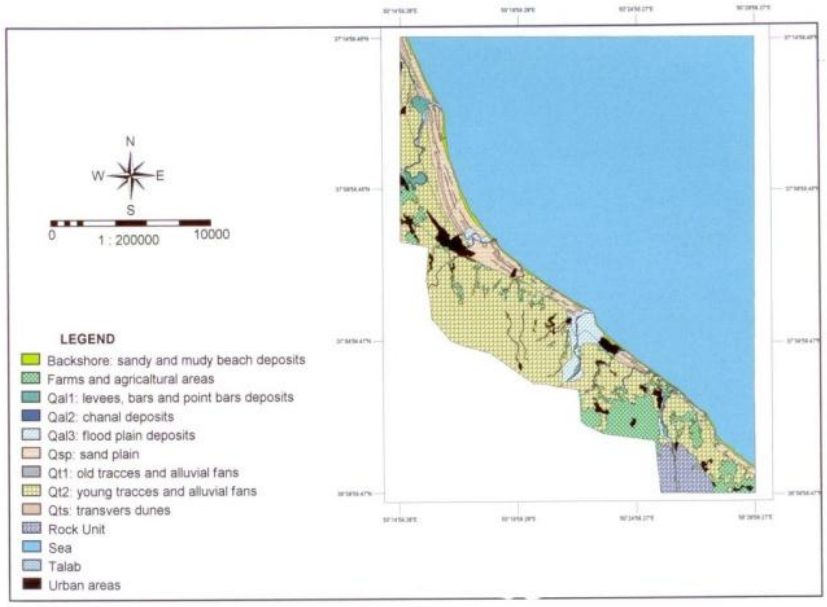

FIGURE 10 MAP OF SEDIMENTARY UNITS AND GEOMORPHOLOGY SHAPES IN RUDSAR -ZONE ON AERIAL PHOTOGRAPHY(1994)

The summary of investigation in the coastal areas of Guilan Province shows deposit morphology bars. In the above tables, the sum of changes are shown as (+) and (-) in which (+) indicates an increase in the extent of retreat and (-) indicates a decrease in the frequency and dispersion rate of the water proceeding towards the coast. Based on field research and the conclusions derived from it, changes occurring in the units of erosion result from various processes like coastal erosion (water proceeding), sedimentation (water retreat), the creation of new units of erosion, and human activities in the field of building ports, roads, cities, and coming into being of small ponds behind sand dunes and changes in the coastal morphology.

Conclusions

In the recent decades, different natural and human factors have caused an increase in the water level of the Caspian Sea and, hence, its changes. This increasing in the level of water has begun from 1967 and its increasing has resulted in the drowning of a vast area. It is believed that the consistent increase and decrease of the water level in the Caspian Sea, every 30-35 years, occurs simultaneously with hot weather alteration and drought [8]. Now the greenhouse effect is the prominent key factor in the vacillation of the water level in the Caspian Sea. According to the view of Kozarev, the contribution of climate in sea level changes is about 85%. In addition to the periodic observation of changes in the Caspian Sea, the sudden changes can also transform the morphology of the coasts and make many areas useless [9]. With the proceeding of water, some problems can be observed, like drowning of many residential and commercial areas in Anzali and Astara and the gardens and farmlands from Langroud to Roudsar, the creation of fetid water and transformation of lands in Chamkhale, river-basins of Astara, Kiashahr and Lasko-Kalaye, the growth of reed and osier in the lands under influence of water proceeding and drowning of many farm lands. Due to sand and gravel collection from the river mouths, sea water penetration and proceeding has increased and has caused serious changes in the coast's morphology and changes in the dispersion and kind of vegetation in Guilan's coastal areas[4]. The retreat of dunes behind the coasts has led to unassailability of coasts and proceeding of water and basic transformations in dispersion and has made the place of wave break deep and long. The collection of sand and gravel from the coastlines, too, has led to a change in the sea level and its advancement has caused erosion in many coastal areas and resulted in the drowning of the coastline. In the coastal areas of Guilan, large waves have played a considerable role in coast morphology[10]. The created waves, regarding the water proceeding in recent decade, have led to the transfer of river's deposits and the parts which have terrestrial and drought source and are observed across Guilan coasts. In some coastal areas from west to east, the deposits of rivers are transferred by waves to different points and accumulated there, and this dispersion of deposits has a considerable role in changing the level of water. Regarding transferring of deposits in river mouth and the place of entrance to coast, these deposits accumulate. Most of these rivers from the lands join the sea at the river mouth. The transfer of deposits is carried out by sea currents and waves which are accumulated in some parts

of the coast creating a vast area which in turn is considerable from a morphological point of view.

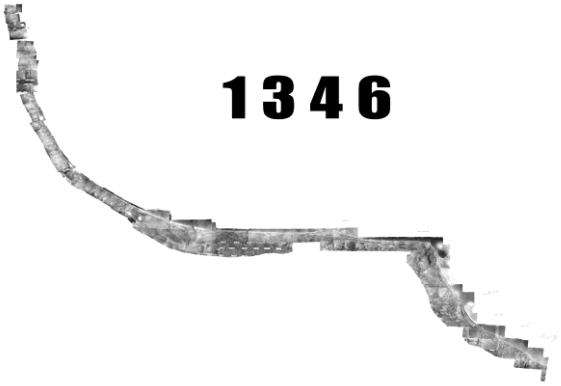

FIGURE 11- ARIAL PHOTOS OF THE STUDY AREA IN 1967

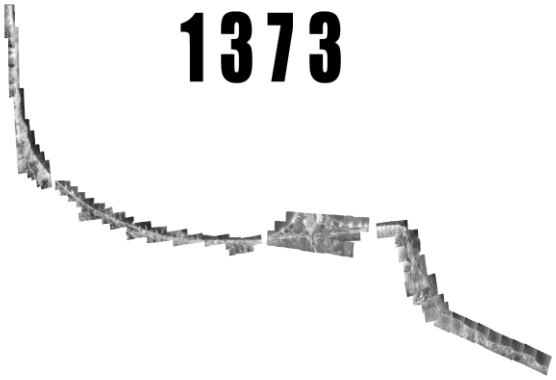

FIGURE 12- ARIAL PHOTOS OF THE STUDY AREA IN 1994

REFERENCES

[1] A. N. Kozarev.AndF.B.Makarova.(1988).About the change of the level of the Caspian Sea and the possibility of forecasting it. Proceedings, Geographical series,5. Moscow State University.

[2] I. A. Shiklomanov, (1981). The effects of man on Basin Runoff and on the water Balance and water stage of the Caspian Sea, Hydrological science.Bulletin, Vol 26. No3

[3] D. Ya. Ratcovich., L. S. Zhdanova., V. Ye.privalskiy. (1973).Waterlevel fluctuations of the Caspian sea. VODNYYE Resursy, No. 3.

[4] W. RFerren.. R. A. Leidy. (2001). classification of California wetlands with coward in et method. www.mip.berkeley.edu

[5] I. s. Ihdanova; v. ye. Privalsky; D. ya. Ratcovich (1976). Investigation of level fluctuations in closed Bodies of water on the Basis of stochastic models of the Elements of the Hydrologic;soviet Hydrology–vol. 15, No. 3.

[6] Bird, (2000). Coastal geomorphology an introduction. Wiley and Sons Ltd. 322P

[7] Y. I. Ignatov; p. A Kaplin; S. A Lukyanova, G. D. solovieva. (1993). Evolution of the Caspian Sea coasts under conditions of sea-level Rise Model for coastal change under Increasing. Moscow state university SR) vol.9. No. 1.

[8] S. Berg, (1960). Level of the Caspian Sea in historical maps. In: selected proceedings. Vol. 3. Moscow, Russia: Academy of Sciences of the USSR, 281 – 326.

[9] Environmental Baseline Analysis of the Caspian Sea Region. internet, CEP. 2002

[10] P. Bruun, (1962). The Sea level rise as a cause of shore erosion. Proceedings, American society of Civil Engineers, Water ways and Harbour Division, 88: 117-130.

A.R. Ghodrati: Scientific member of Agricultural and natural resources, research center of Guilan. Rasht, Iran. Scientific activity: scientific research in watershed implementing research projects in the field of water and coastal management, lecturer in university.

Payam Alemi Safaval was born in 1984 in Rasht, Iran.

He received his BSc in Geography-Cartography and he is currently a MSc student in Remot Sencing and GIS Engineering, water and soil branch in Islamic Azad University, Science and Research Branch, Tehran, Iran. He is currently a member of Guilan Center of Geoscience, Geological Survey of Iran. He has already published several papers in the field of using Remot Sencing and GIS in environmental engineering. He has also participated in different research projects in Geoscience.

Dr. Mir Ahmad Lashteh Neshaei was born in 1965 in Rasht, Iran.

He received his BSc and MSc in Civil Engineering, Hydraulic Structures from AmirKabir University of Technology in Tehran, Iran. He did his PhD in Coastal Engineering at Imperial College of Science, Technology and Medicine, London, U.K in 1998. He has also got his PostDoc. from Kagoshima University in Japan in 2000, in the field of Coastal Hydrodynamics.

He has extensively worked on different research projects regarding the design of seawalls and other shore protection structures as well as dams, canals and related hydraulic structures and published several conference and journal papers.

Dr. Lashteh Neshaei is a member of the Iranian Hydraulic Association. He is currently teaching at the Civil Engineering Department, Faculty of Engineering, The University of Guilan, Rasht, Iran as an associate professor.